UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

MODEL STUDIES OF THE BEND AT STATION 2487+9300 OF THE NORTH UNIT MAIN CANAL

DESCHUTES PROJECT, OREGON

Hydraulic Laboratory Report No. Hyd. 228

ENGINEERING AND GEOLOGICAL
CONTROL AND RESEARCH DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

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and Research Division
Denver, Colorado
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Hydraulic Laboratory
Compiled by: E. J. Rusho and
A. N. Flasco
Reviewed by: A. J. Peterka

Subject: Model studies of the bend at Station 2487+93.00 of the North Unit Main Canal--Deschutes Project, Oregon.

INTRODUCTION

The North Unit Main Canal, part of the Deschutes Project in central Oregon, Figure 1, originates at the North Canal diversion dam and extends North for 65 miles to Madras, Oregon. The canal, with a normal capacity of 703 second-feet, provides water for irrigation of 20,000 acres of semiarid land in the vicinity of Madras. To prevent damage to the unlined canal several check and chute structures are required throughout its length. The cross-section is trapezoidal in shape with a bottom width of 30 feet and side slopes of 1-1/2 to 1.

This report describes studies made to determine the flow conditions in the region of the 55° sharp angle bend at Station 2487+93.00 of the canal, Figures 2 and 3. The flow at this point presented a problem because of high velocities resulting from a chute just upstream from the bend. It was believed the abrupt turning of the flow might cause unsatisfactory flow conditions at or below the bend with possible serious scour or overtopping of the canal banks. Damage could only occur in the canal since the bend is of concrete.

Model studies were made to determine whether overflow conditions existed and if corrective measures were required. Satisfactory solution of the problem was obtained from the tests with only minor revisions required in the structure.

CONCLUSIONS AND RECOMMENDATIONS

Wave action was present in the bend and canal section for all discharges, but was less at the maximum flow of 703 second-feet than at the two intermediate flows of 530 and 350 second-feet. The magnitude of the waves was not great enough to cause overtopping of the walls of the bend or the banks of the canal.

Concentration of flow against the outside wall of the bend raised the water surface sufficiently to cause overtopping of the wall when operating at maximum discharge. To correct this condition it is recommended that the right training wall height be increased 1 foot from Station 2487+83.04 to Station 2489+10.21 on the outside of the bend.

No unsatisfactory concentration of flow in the canal section resulted from the turning of the water in the sharp bend. Scour was present in the canal at the downstream end of the transition section for all discharges. To reduce the erosion it is recommended that riprap be placed on the bottom and sides of the canal for a distance of 50 feet, starting at Station 2488+52.21.

THE MODEL

Description and Design

The model, Figure 4, on a scale of 1 to 16, included the downstream half of the chute, the stilling-basin between the chute and bend, the 55° bend shown in Figures 2 and 3, and a portion of the canal downstream from the bend. Water entered the chute through a wooden head box lined with sheet metal. The stilling-basin at the toe of the chute, the 55° bend, and the canal section were contained in the tail box, also a lined wooden box. The training walls, stilling-basin, and bend were made of wood faced with sheet metal. The transition between the bend and the canal, including the bottom, was molded in concrete. The canal bottom was of sand and the side slopes of concrete. Water supplied to the model was measured by accurately calibrated venturi meters and a point gage was used to determine the elevation of the water surface in the canal section.

The vertical height of the chute section was increased 4 feet over that shown in the prototype to insure the proper velocity of flow entering the stilling-basin. In a small scale model it is impossible to reproduce the roughness of the prototype to scale. As a result, the friction losses in the model are greater than the corresponding prototype losses. The increased vertical fall in the model compensated for the excessive model loss, thereby providing the proper velocity, and hence, the proper energy for the flow entering the stilling-basin.

Design Check

To determine whether the proper increase in chute slope had been used in the model, measurements were made to determine the velocity of flow entering the stilling-basin. From the depth of water, measured at the toe of the chute for the maximum discharge of 703 second-feet, the area was determined, and the velocity was computed to be 64 feet per second. This close agreement with the calculated prototype velocity of 65 feet per second indicated that the slope increase in the model was satisfactory.

THE INVESTIGATION

General

The model studies were made for various discharges up to the maximum of 703 second-feet. Particular attention was given to the tests at maximum discharge since the prototype was intended to operate at this condition and also, the velocities were highest at this discharge. The lowest discharge tested was 175 second-feet. The water surface in the canal was maintained at the depth shown in the depth versus discharge table of Figure 4.

Three factors were observed in judging the performance of the model. They consisted of observation of flow conditions at and below the bend, wave action in the bend and canal, and scour in the canal bottom. Photographs of four different discharges recorded the performance of the structure.

A modification to the original design was tested consisting of four curved guide vanes placed in the bend, but only slight changes in flow conditions resulted. Final modification to the structure was a 1 foot addition to the height of the outside wall of the bend and riprap on the canal section downstream from the bend.

Description of Tests

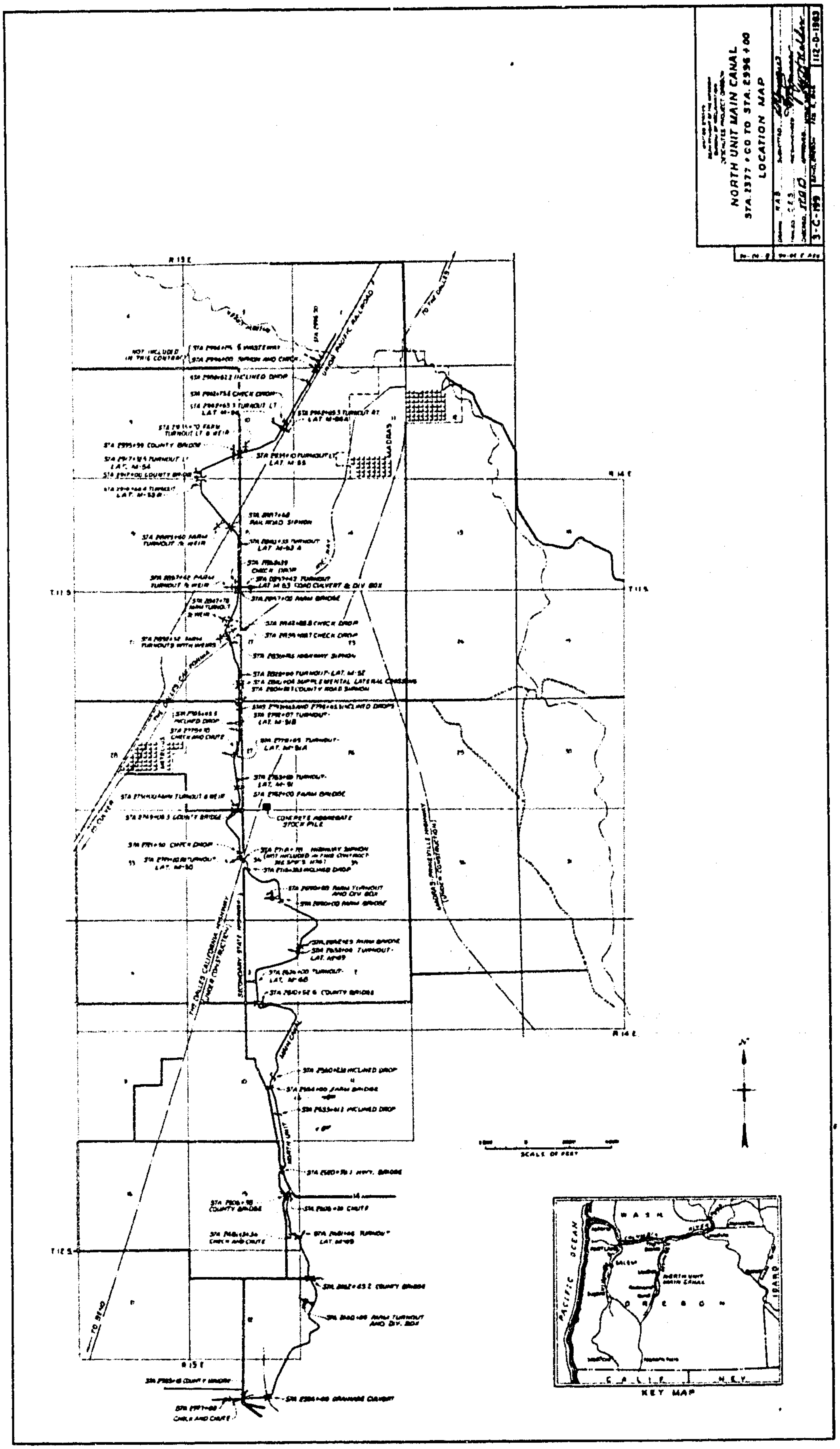
Original bend. The operation of the model at discharges of 703, 530, 350, and 175 second-feet are shown in Figures 5, 6, and 7. Wave action occurred at all discharges; however at 530 and 350 second-feet the waves were of greater magnitude than for the other two flows. Although the waves presented an objectionable appearance, it was believed they would not have any destructive action on the side slopes of the earth canal.

Flow of water around the bend was satisfactory except at maximum discharge, Figure 5. The flow of water against the outside wall of the bend caused a rise in the water surface resulting in overtopping of the wall. This condition was corrected by increasing the height of the wall 1 foot prototype between Stations 2487+83.04 and 2489+10.21.

For all test discharges scour was observed in the canal bottom just downstream from the transition section. The greatest scour occurred at the maximum discharge of 703 second-feet. Riprap placed below the transition in the first 50 feet of the canal reduced the erosion of the canal bottom to a negligible amount.

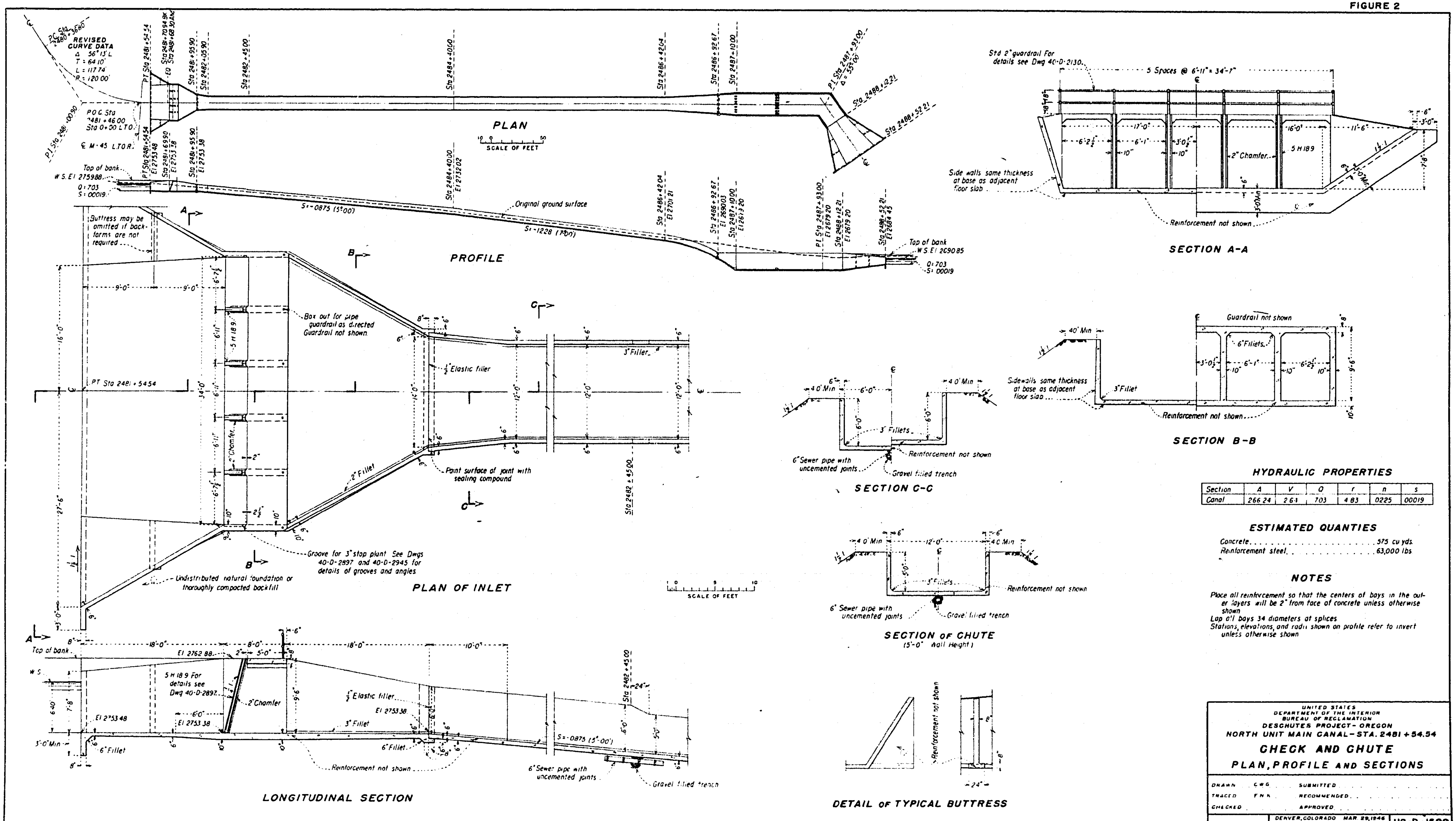
Vanes at bend. Four, equally spaced, curved vanes were installed in the bend, Figure 4. No noticeable changes in the action or magnitude of the waves resulted from the use of the vanes. With no riprap at the end of the transition scour in the canal bottom was still present. The vanes prevented the water from flowing over the outside wall of the bend when using the original wall height and flow distribution in the canal section was improved. However, these improvements were not sufficient to justify the added expense of installing vanes.

FIGURE I



NORTH UNIT MAIN CANAL
STA. 2377+00 TO STA. 2996+00
LOCATION MAP
UNION PACIFIC RAILROAD
CONCRETE AGGREGATE STOCK PILE
SCALE OF FEET
KEY MAP
PACIFIC OCEAN
WASH.
OREGON
CALIF.
NEV.
IDAHO
NORTH UNIT MAIN CANAL

FIGURE 2



HYDRAULIC PROPERTIES

Section	A	V	Q	r	n	s
Canal	266 24	2 64	703	4 83	0225	00019

ESTIMATED QUANTIES

Concrete . . . . 575 cu yds.
Reinforcement steel . . . . 63,000 lbs

NOTES

Place all reinforcement so that the centers of bays in the outer layers will be 2" from face of concrete unless otherwise shown
Lap all bays 34 diameters at splices
Stations, elevations, and radii shown on profile refer to invert unless otherwise shown

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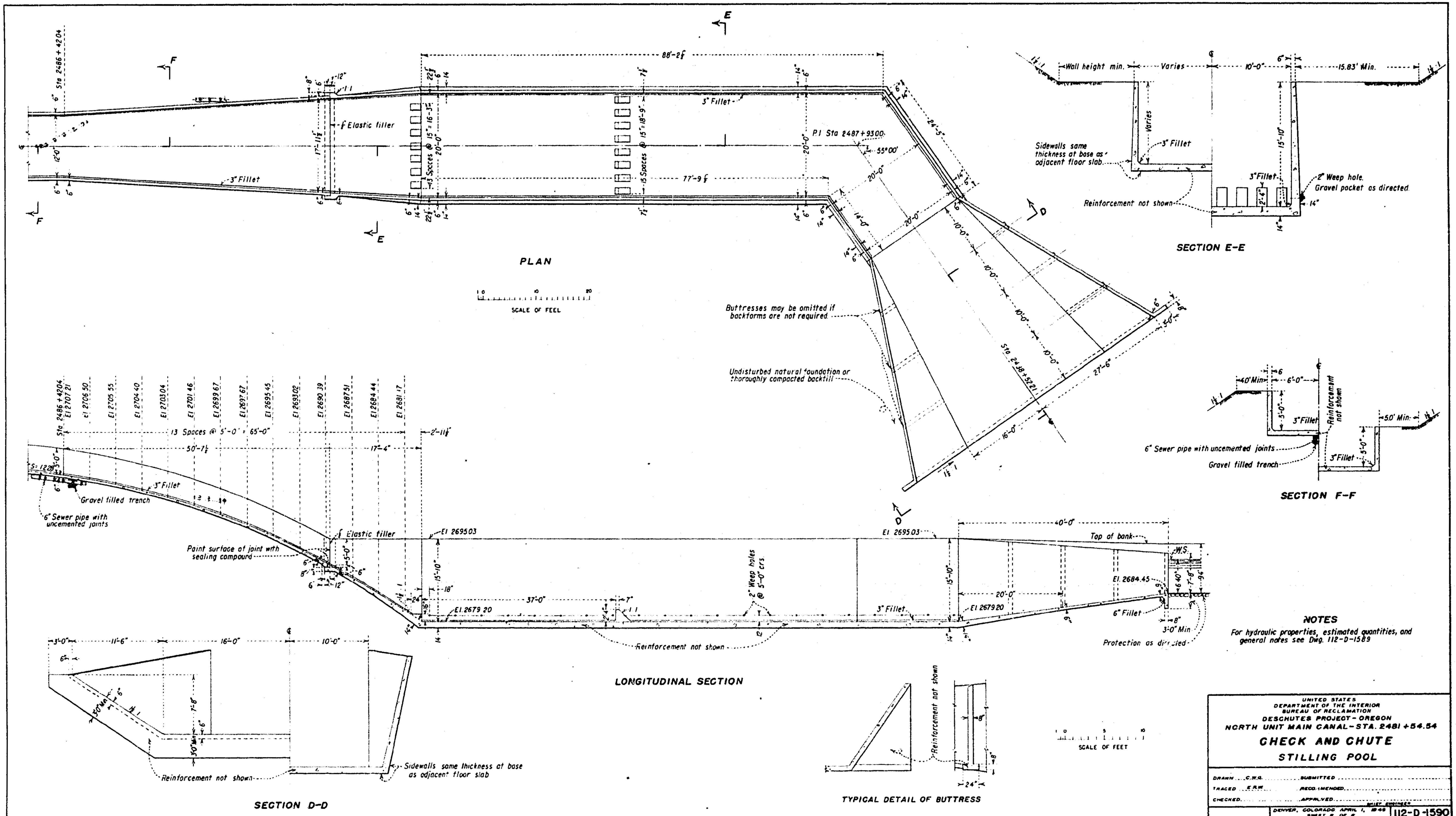
DESCHUTES PROJECT- OREGON
NORTH UNIT MAIN CANAL-STA. 2481+54.54

CHECK AND CHUTE
PLAN, PROFILE AND SECTIONS

DRAWN C.W.G. SUBMITTED
TRACED F.N.K. RECOMMENDED
CHECKED APPROVED

DENVER, COLORADO MAR. 29, 1946
SHEET 1 OF 2
112-D-1589

FIGURE 3


PLAN
SCALE OF FEET
LONGITUDINAL SECTION
SECTION E-E
SECTION F-F
SECTION D-D
TYPICAL DETAIL OF BUTTRESS
SCALE OF FEET
Buttresses may be omitted if backforms are not required
Undisturbed natural foundation or thoroughly compacted backfill
Sidewalls same thickness at base as adjacent floor slab
Reinforcement not shown
2" Weep hole. Gravel pocket as directed
6" Sewer pipe with uncemented joints
Gravel filled trench
Paint surface of joint with sealing compound
Elastic filler
Protection as directed
Top of bank
NOTES
For hydraulic properties, estimated quantities, and general notes see Dwg. 112-D-1589
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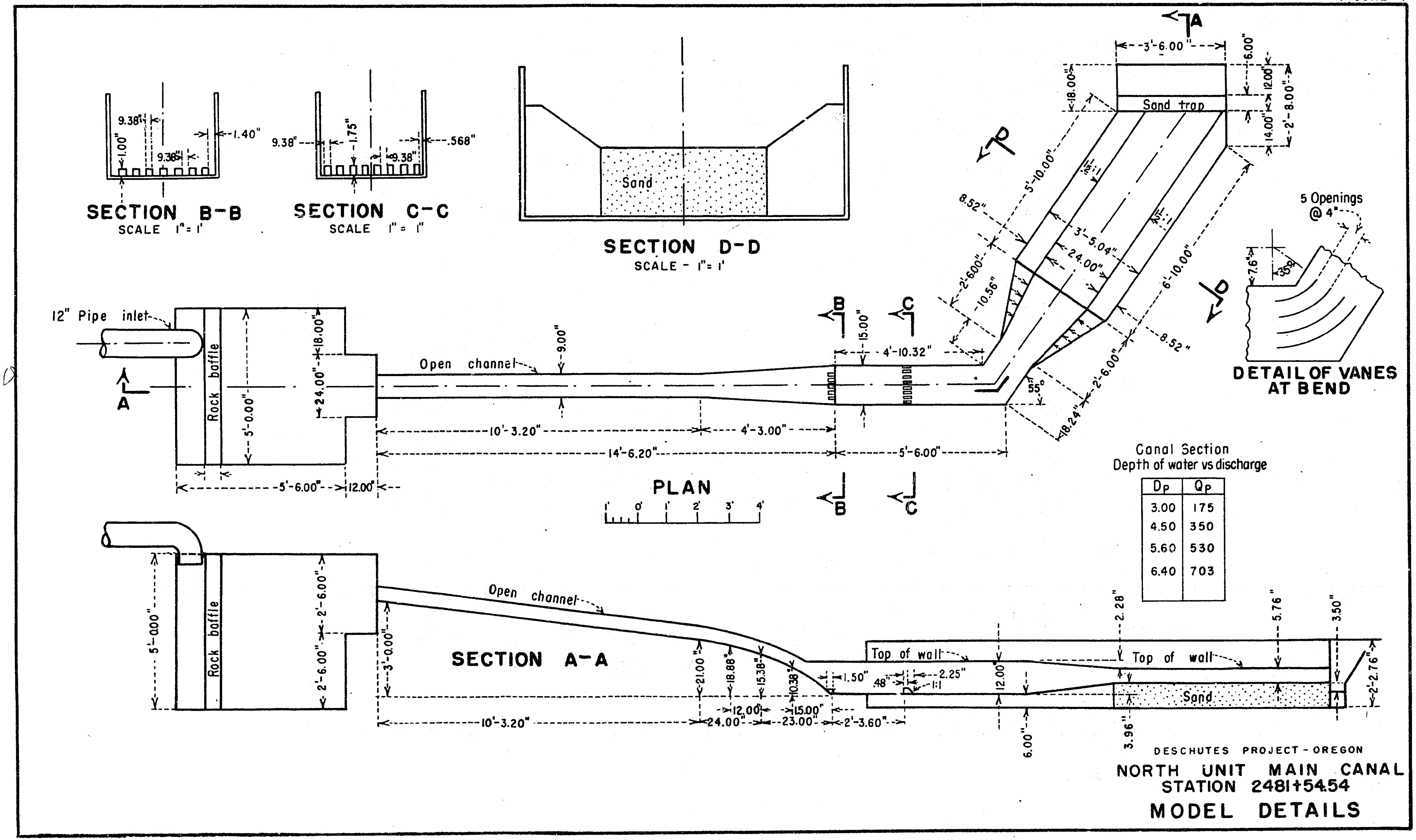
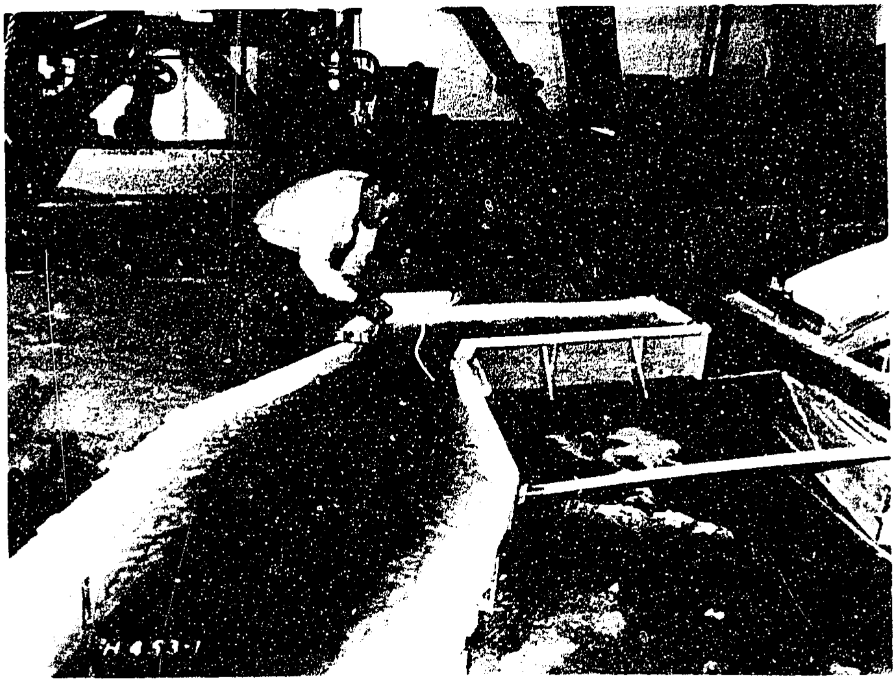
CHECK AND CHUTE
STILLING POOL
112-D-1590

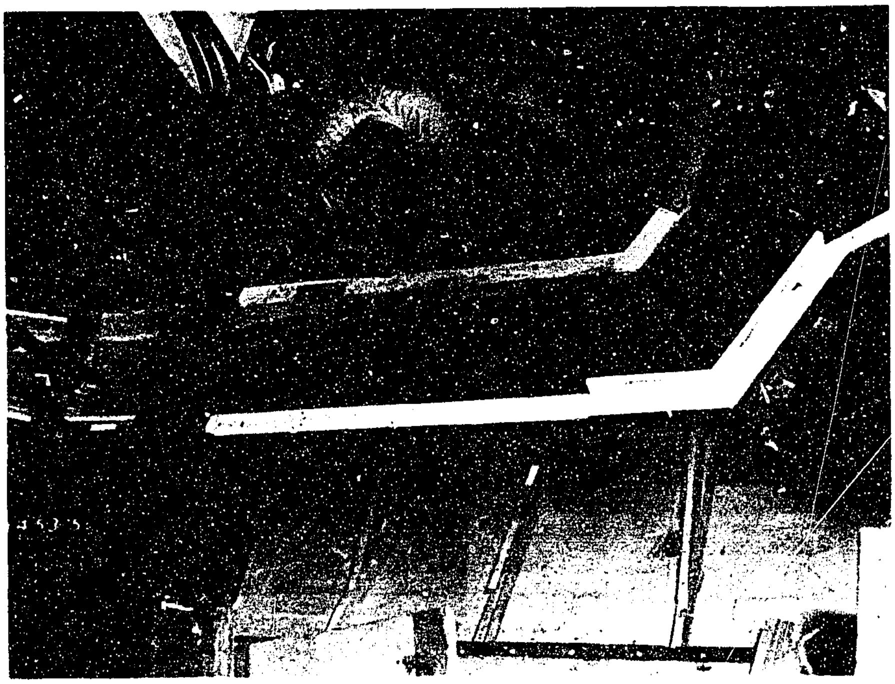
FIGURE 4



Dp	Qp
3.00	175
4.50	350
5.60	530
6.40	703

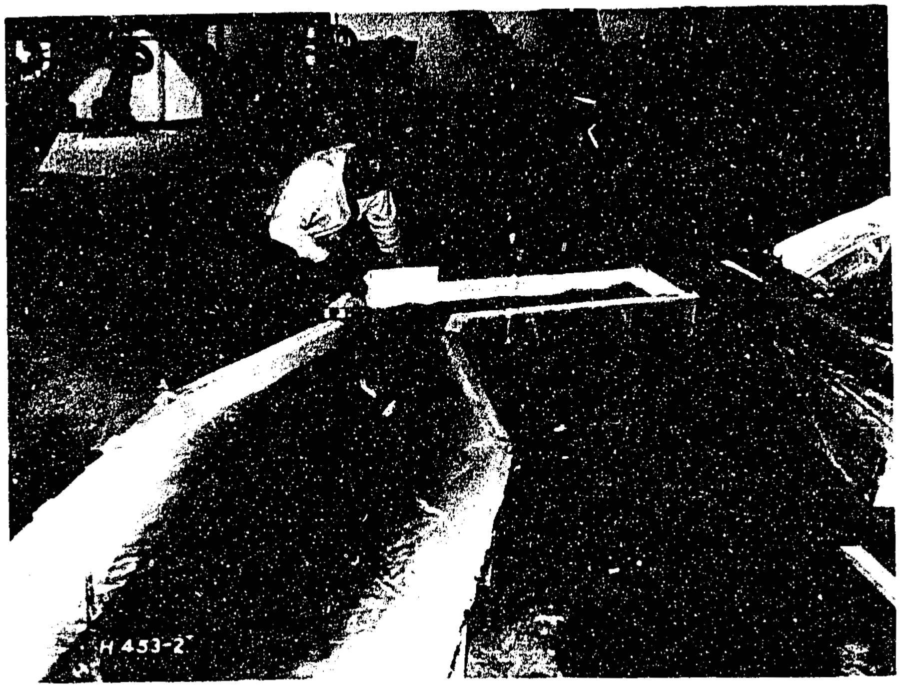


A - Model Operation
Q = 703 c.f.s.

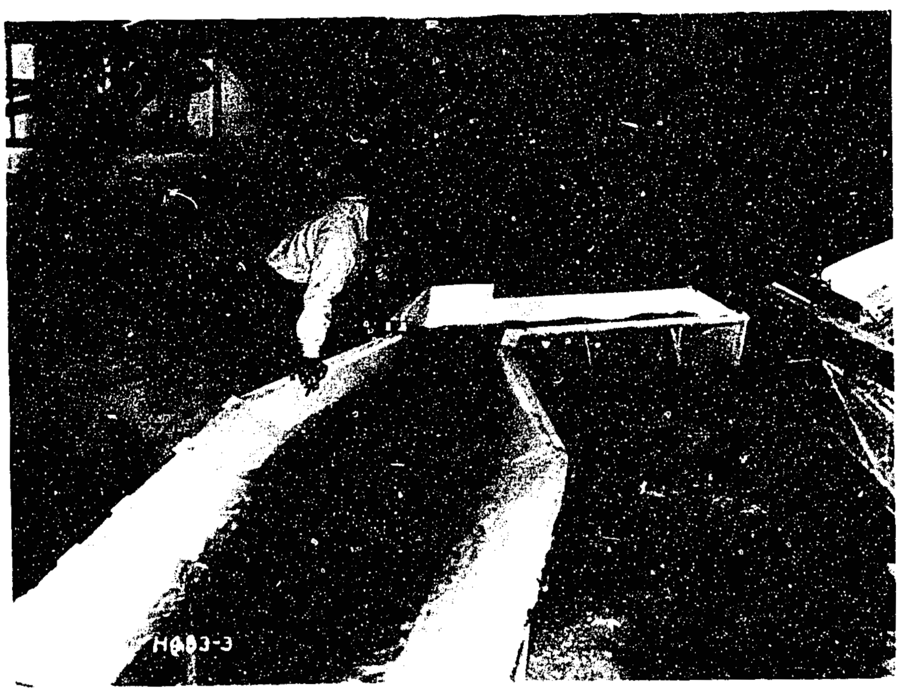


B - Model Operation
Q = 703 c.f.s.

NORTH UNIT MAIN CANAL
DESCHUTES PROJECT



A - Model Operation
Q = 530 c.f.s.



B - Model Operation
Q = 350 c.f.s.

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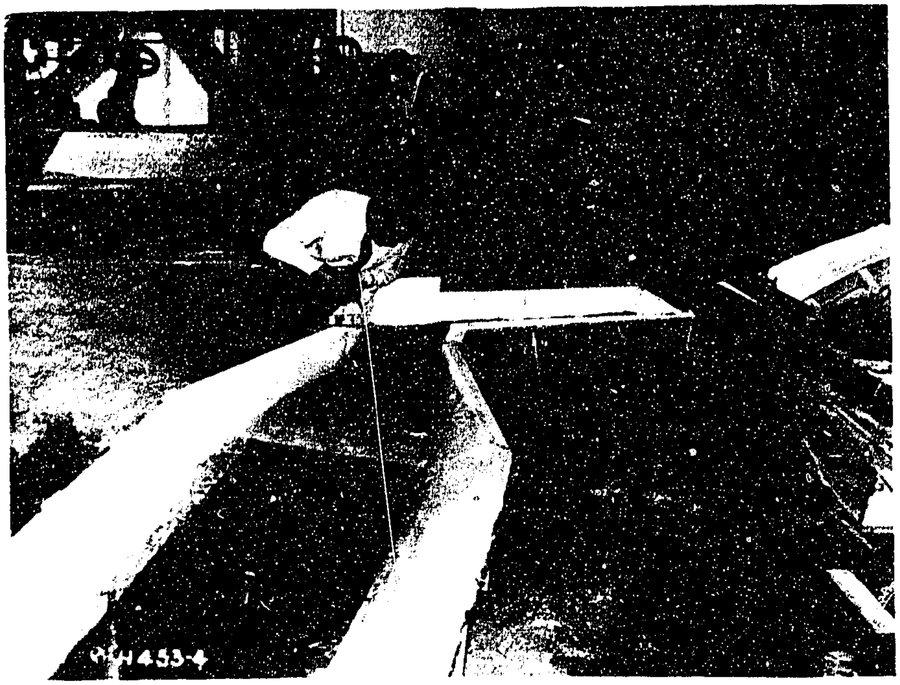
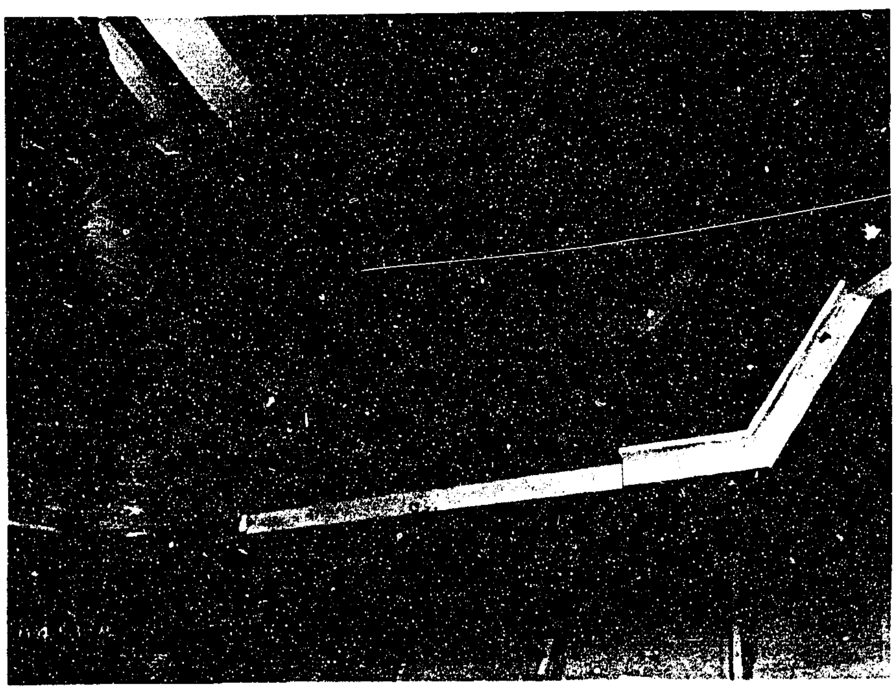


A - Model Operation
Q = 175 c.f.s.



B - Model Operation
Q = 175 c.f.s.

NORTH UNIT MAIN CANAL
DESCHUTES PROJECT